Proceedings of the 12th International Conference on Music Perception and Cognition and the 8th Triennial Conference of the European Society for the Cognitive Sciences of Music, July 23-28, 2012, Thessaloniki, Greece
Cambouropoulos E., Tsougras C., Mavromatis P., Pastiadis K. (Editors)

Effects of Observed Music-Gesture Synchronicity on Gaze and Memory

Lauren Hadley,[*1] Dan Tidhar,[#2] Matthew Woolhouse[†3]

[*]*Department of Psychology, Goldsmiths College, University of London, England*
[#]*Faculty of Music, University of Cambridge, England*
[†]*School of the Arts, McMaster University, Canada*
[1]lauren.hadley@cantab.net, [2]dut20@cam.ac.uk, [3]woolhouse@mcmaster.ca

ABSTRACT

Following a previously undertaken dance experiment, which found that music-gesture synchronicity (as in dance) enhanced social memory (Woolhouse & Tidhar, 2010), this study examined the factors which could be seen to underlie this effect. Both gaze time and gaze quality were considered. The experiment involved two videos of a dancer presented beside each other, accompanied by an audio track in time with only one of the two visuals. The visual stimuli each involved the same dancer, clothed in two similar outfits of different colours. As participants viewed the stimulus their eye-movements were recorded using a webcam. Subsequently, the subjects' memory of the dancer's clothing was tested by them colouring-in two schematic diagrams of the dancer, one for each of her outfits.

Two hypotheses were tested in this experiment: (1) that gaze would be directed more towards the video in which the dancer and audio were matched ('synchronised dance video' or SDV), and (2) that memory of clothing would be better for the synchronised dance video than for the 'desynchronised dance video' (or DDV), i.e. the video in which the dancer and audio were mismatched. The results indicated a tendency for participants to focus for longer on the SDV than the DDV, but did not show a correlation between music-dance synchronicity and memory of clothing. Post hoc analysis suggested that instead, size or area of clothing item correlated to its memorability. These findings are discussed in relation to various hypothesised modes of entrainment.

I. INTRODUCTION

Behavioural coordination is an important element of human interaction, evident in actions as diverse as group musical performance, playing football, and jointly washing the dishes (Sebanz, Bekkering & Knoblich, 2006). Moreover, synchronisation of behavioural coordination to a regular pulse, given visual cues, has been found to occur subconsciously. In other words, if two people are engaged in an activity whilst visually attending to each other, it is common for them to synchronise to the same rhythm for the activity, even if their personal rhythmic preferences would otherwise differ. This effect was found more than twenty years ago through a hand-held pendulum study (Schmidt et al., 1990), and has been replicated by a number of subsequent studies. One innovative experiment involved two participants sitting beside each other in rocking-chairs, and being told to rock independently (Goodman et al., 2005). Interestingly, even when the natural rocking frequency was altered between the two chairs, a convergence to the same speed was found.

In 2008, Macrae at al. studied the social consequences of this phenomenon by investigating the link between movement-synchronisation during social interaction, and person perception. Through a hand-waving study, participants were found to remember significantly more about both the appearance of the experimenter and the verbal stimuli she provided when in the synchronised participant-experimenter condition. A study by Kirschner and Tomasello also found coordinated rhythmic interaction to enhance prosocial behaviour, in this case specifically relating to empathy and cooperation. Synchronisation induced through singing and dancing, as opposed to talking and playing, had a significant positive effect on the subsequent interactions of its four-year-old participants (Kirschner & Tomasello, 2010).

The current study examined the attentional and prosocial effects of dance. The historical function of music and dance has long been debated, with a wealth of proposals being put forth. For example, dance having evolved as a bonding experience has been suggested (Freeman), as has dance as a display of courtship (Catchpole and Slater). However, regardless of its evolutionary history, it is prevalent amongst numerous cultures, Arom stating that no human society 'that does not express itself through dance' is known (Clayton, Sager & Will, 2005, p.53). Dance is perhaps the most obvious form of coordinated behavioural synchronisation to a regular rhythm, and remains an important aspect of social interaction today. A greater understanding of its effects on social behaviour could therefore be employed to facilitate social development in specific populations, or simply to enhance social understanding more generally.

A recent study by Woolhouse and Tidhar (2010 – here referred to as Dance I) investigated the relationship between 'music-induced motor coordination' (i.e. dancing in time), and person-perception. Following a hypothesis that those who dance together, remember more about each other, silent disco technology was employed to investigate the issue in a real-world setting. The experiment involved groups of 10 people unknowingly split into two groups of 5, with each participant being provided a sash and set of radio headphones. The headphones were covertly programmed to one of two music channels: one playing the Spice Girls, the other playing Chris de Burgh, 5 participants listening to each. Participants danced for approximately 45 seconds at each of 10 positions on a marked dancefloor, and were subsequently tested on their memory of the sash-colour and sash-symbol of each of the other participants. This memory test was administered through a questionnaire including facial photographs of each other participant. The study found interpersonal entrainment to have a positive effect on incidental memory, with people who listened to the same music (and therefore danced at the same tempo) remembering more about each other than those who listened to different music (and therefore danced at different tempo). This supports social theories of dance, although the specific reasons for this result were not identified.

This experiment was devised to further this research through study of the factors that could affect memory during the observation of dance. The active paradigm of Dance I was adapted to an observation paradigm in order to study the interaction between dance synchronicity and gaze direction, in conjunction with dance synchronicity and memory. Specifically considered was whether gaze-time, or quality of gaze, enhances visual memory of synchronous vs asynchronous dancers.

Two hypotheses were tested in this experiment: that music-gesture synchronicity would result in greater gaze time than music-gesture desynchronicity (i.e. people will look at the SDV longer than the DDV), and that music-gesture synchronicity would have a positive effect on incidental memory (i.e. people will remember more about synchronous dancer's clothes).

II. METHOD

A. Design

A between subjects design was implemented to examine the effect of music-gesture synchronicity on gaze time and memory for clothing. The side of the participant that the synchronized dancer was presented was a between subjects variable, and the two dependent variables were gaze time directed at each dancer, and memory for clothing.

B. Participants

18 participants were chosen for this study, consisting of 8 males and 10 females, aged between 19 and 25 (mean 20.2). All participants had normal or corrected to normal hearing, had no auditory deficits, and were students at the University of Cambridge. Each had at least 6 years' worth of previous musical training, with 17 having upwards of 10 years' worth.

C. Stimuli

The visual stimuli were presented on two Iiama screens, with resolutions of 1600x1200. The auditory stimuli were presented through two Eridol speakers, set on either side of two monitors and a MacBook Pro (Figure 1). Eye movement was captured using the inbuilt webcam of the laptop.

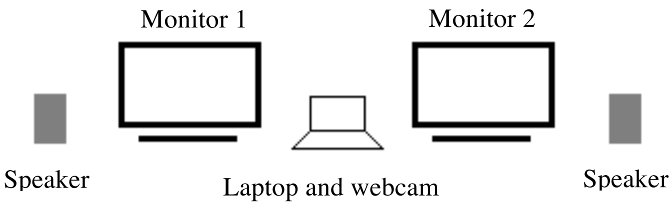

Figure 1 Experimental Layout, consisting of speakers, monitors and laptop.

The visual stimuli were created by recording the dancer with a Sony HDV 1080i camera against a white screen. The dancer was filmed in one outfit (red dress) dancing to one audio stimulus, and in a different outfit (blue dress) dancing to a different but comparable audio stimulus (different tempi). The videos were subsequently edited using FinalCut Pro. This included size adjustment and brightness modification of each video, followed by combining the videos into a 50:50 split-screen. Two permutations of the split screen were created, with the dancers' positions alternated (i.e. red|blue; blue|red). The split-screen stimuli were produced in such a way as to ensure that the dancing between the two began simultaneously. When the experiment was run, the split screen was distributed between the two monitors (Figure 2).

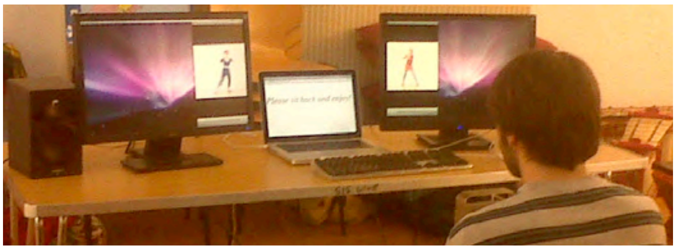

Figure 2 Setup of experiment

Three contemporary musical extracts were used to create the auditory stimuli: *Unnatural Selection* by Muse (149bpm), *Dimestore Diamond* by Gossip (97bpm), and *The Water* by Hurts (74bpm). These songs were chosen due to their disparate tempos, which were categorised as fast, medium, and slow respectively. The tracks were ordered FSM and presented twice, each song lasting 60 seconds and being followed by a 5 second fade into the next. In total the audio lasted 6 minutes 25 seconds.

Each experimental condition therefore consisted of a split screen of two dancers, wearing different coloured outfits, with only one dancer being in synchrony with the music. When the dancer in the red dress was originally filmed, she danced to the audio stimulus described. It was therefore the dancer in the red dress that danced in synchrony for both conditions. In order to maintain the quality of the audio, auditory stimulus 1 was re-applied once the split-screen had been created, matched to the original audio.

D. Procedure

In the experiment itself participants were read a short set of instructions and asked to sign a consent form (relating to eye-movement recordings). The exact nature of these recordings, i.e. for analysis of eye movement, was not revealed to the participant due to possible hypothesis guessing. Instead, participants were seated in front of the equipment and told to 'sit back and enjoy the music and dancing' in anticipation of a musical questionnaire. The audio-visual stimulus was then started by the experimenter. The two conditions (red|blue, and blue|red) were alternated between participants to ameliorate the effect of left/right presentation order. When the video finished, the participant was taken to an adjoining room and asked to colour in a schematic of the dancers. Participants were provided with 10 felt pens and told to put a question mark on any items of clothing for which they could not remember the colour. Finally, all participants completed a personal musical experience questionnaire. The experiment took approximately 15 minutes in total per participant.

III. RESULTS

A. Gaze Direction

Gaze direction was examined by analysing the recorded video of each participant manually using a game clock. Any time that the participant was not focussed in the direction of one of the monitors the clock was stopped, and was resumed when gaze was once again focussed on the visual stimuli. Each video was studied twice, being run a third time if a disparity of greater than 8 seconds was found between analyses. These results were averaged for subsequent investigation. When gaze times of individual participants were compared (i.e. synchronised dancer vs. non-synchronised dancer, or left screen vs. right screen) they were normalised through conversion into a percentage. 100% was taken to be the total time that the participant focused on the dancers, which, due to distractions, varied significantly between participants.

Overall, it was found that of the time spent attending to the dancers, participants focused on the synchronised dancer for 52.09% of the time, and the unsynchronised dancer for 47.91% of the time (Figure 4). This is equal to over 15 seconds of extra time spent focussed on the synchronised dancer over the 6 minutes and 25 seconds of the experiment. Although the results of the gaze analysis did not reach significance (a one-tailed t-test resulting in t(34)=1.455; *p*=0.08), a trend of participants attending to the synchronised dancer for longer was indicated (11 of 18). The length of extra time that the participants focussed on this dancer ranged from 7 to 126 seconds. Of these participants, the average extra time spent focused on the synchronised dancer was 58 seconds.

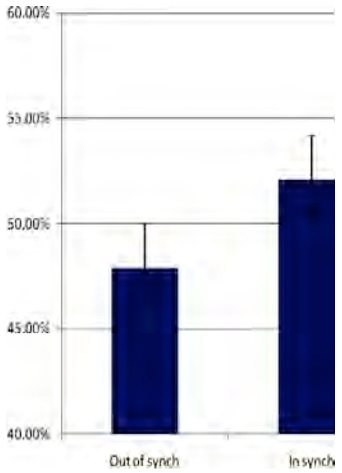

Figure 3. Average percentage of time spent focused on each dancing condition.

Additionally, correlation between gaze direction (left/right) and gaze time was examined independent of synchronicity. This was to examine whether a left/right preference was evident in gaze direction overall. No significance was found, t(34)= -0.3851; *p*=0.70.

B. Memory task

4 items of clothing were examined in the memory task: dress, belt, leggings, and hair piece. Although a bracelet had also been considered, in the pilot a 'floor effect' was found and the item consequently omitted (replicating the finding of Louw & Ventner, 2004, for jewellery to be more poorly remembered than other items of clothing). Figure 4 shows a screen-shot of the dancer wearing the outfits as presented in the experiment.

Figure 4. Visual experimental stimulus, condition 1.

For data analysis, colour families were defined under which clothing colour responses would be deemed correct; for example, for the grey belt, responses of both grey and light blue were accepted. This allowed a relatively large choice of felt-tip pens to be provided (10) in an attempt to lower the probability of arbitrary guesses proving correct.

Better memory was not found for the synchronous dancer. Almost the same amount was remembered for each dancer, with an average of 63.89% being correctly remembered of the synchronous dancer, and 68.06% being correctly remembered of the unsynchronised dancer. One-tailed t-tests designed to investigate whether memory of clothing item was affected by dancer synchronicity did not indicate any significant difference in the populations, though a 'ceiling effect' on memory of dress colour suggests that the task was too easy (Figure 5).

Figure 5. Percentage of clothing item colours correctly remembered for the synchronised and desynchronised dancer.

	Percentage correctly remembered		**T-test**
	Synchronised	Unsynchronised	***p value***
Dress	100	100	N/A
Belt	44.44	50	0.37361
Hair piece	44.44	66.67	0.09495
Leggings	66.67	55.56	0.25406

Since no significant difference was found in memory of clothing between the two conditions (synchronised and desynchronised), the results were combined in order to examine the overall relationship between clothing item and memory of colour. A one-factor (clothing item) within-subject ANOVA was applied. In the analyses none of Mauchly's Test of Sphericity *p*-values (for homogeneity of covariance) were significant, and therefore the usual F test (sphericity assumed) was applied. In this analysis clothing item proved significant: F(3,51)= 7.46; *p*<0.001. The Tukey HSD comparison was applied to test all possible two-way comparisons. The comparisons between: dress & belt, dress & hair piece, and dress & leggings each resulted in p<0.05. Other comparisons did not show significance. This further indicates that dress colour was too easy a memory task. It also suggests that size or area of clothing item correlates to its memorability.

Analysis of male vs. female memory of clothing was also undertaken due to a reported correlation between sex and memory of appearance (Mast and Hall, 2006). In the sample investigated within this experiment however, no significant difference was found in clothing memory between the two groups, although on average the female participants were 6% more accurate.

IV. DISCUSSION

Participants indicated an overall preference for watching the synchronised dance video, although it is noted that this result did not reach significance. Given the relatively small number of participants however, these results could be indicative of a trend that would be more clearly visible had a greater sample size been employed. Assuming that this trend is genuine, there are several possible reasons for the effect. One possible explanation could be a form of passive entrainment inducing a preference for the synchronised condition. Entrainment is the synchronisation of a biological oscillator to an external regular beat, and can be either active (involving movement) or passive (without involving movement). Active entrainment has been suggested by Cross to foster pro-social behaviour, creating a 'sense of mutual affiliation' (Cross & Woodruff, 2008), and has been proposed to rely on mutual attention (Kirschner & Tomasello, 2009). It is not known whether the same is true for passive entrainment due to a paucity of research in this area; although greater memory for the synchronised dancer's clothing suggests that this may indeed be the case.

No significant difference was found in memory between the synchronised and unsynchronised dancer. This may indicate that the memory tasks were too easy (dress), too difficult (belt), or that the format used was inappropriate. Participants were intentionally blind to the nature of the experiment, but this may have resulted in attention being drawn away from the visual of the dancer and redistributed to a conscious attempt to understand the experiment's focus.

Alternatively, there may have been an effect of colour itself on attention. Although the styles of the outfits of both dancers were similar, the colours of the outfits were significantly different, as seen in Figure 4. A number of studies have found colours to have connotations, for example red being commonly associated with danger and mistakes, and blue with peace and tranquility (Mehta & Zhou, 2009). The red items of clothing may therefore have drawn greater attention by default, due to its more urgent connotations, possibly resulting in these items being remembered more easily. An effect such as this may provide some rationalisation for the unexpected result of the unsynchronised dancer's (red) hair piece being correctly remembered by 22% more of the participants than the synchronised dancer's (white) hair piece (Figure 5). The way to eliminate this possibility would be to repeat the experiment with the other outfit being in synchrony, i.e. running an exhaustive factorial design of all four possible conditions: each dancer being run in and out of synchrony and on each side of the screen.

V. CONCLUSION

Hypothesis 1, that music-gesture synchronicity would result in greater gaze time than music-gesture desynchronicity, was supported by the results of this experiment, but hypothesis 2, that music-gesture synchronicity would have a positive effect on incidental memory, was not. As previously stated, the hypotheses tested in this project followed an investigation by Woolhouse and Tidhar (2010), with the current experiment being created independently to further research the relationship between memory and dance. However, it is perhaps through a comparison of these two studies that the most interesting conclusions can be drawn. The findings of the current experiment have not replicated the enhanced social-memory results of the previous study, and the possible reasons for this difference will now be discussed.

Firstly, the methods of extracting memory information in the two experiments provided different degrees of recall-assistance, and may therefore have depended on different recall-processes. In Woolhouse and Tidhar's experiment (Dance I), facial information was provided on the answer forms, which may have assisted the process of remembering personal details. In the current experiment however, not only was the same dancer used for both conditions, but facial information was omitted altogether from the answer form provided, negating any possibility of recall facilitation. Furthermore, in Dance I only 2 questions were asked per dancer: colour (with 4 options being provided) and symbol (with 2 options being provided). In the current experiment 4 questions were asked per dancer, with 10 choices being provided for each (although subsequent analysis sorted colours into fewer groups through consideration of acceptable errors).

Secondly, an important difference between these experiments is the type of memory task itself. Whereas a clearly artificial setup was induced in Dance I, in the sense of participants having to wear striking fluorescent sashes during their participation (attention being drawn to the importance of the sash both through its provision and its colour), the participants' lack of knowledge of the experimental focus within this experiment as well as the creation of a naturalistic clothing situation could have resulted in a more general lack of attention to appearance. This is, however, disputed by the ceiling effect in the dress memory data.

Finally, and perhaps most fundamentally, different paradigms were used in the two studies. The use of eye-observation data to gauge gaze differences between synchronised and desynchronised dancing conditions was considered a viable design to further explore the phenomenon of audio-visual synchrony enhancing social memory. However, although both experiments involved observation of synchronous and non-synchronous dancing, the way in which this was studied varied considerably. The difference in results may have been due to the fact that it was not the viewing of a dancer in synchrony with the participant's heard music that caused enhanced person-perception in Woolhouse and Tidhar, but the *movement* of the participant *in time with* the dancer. This is a critical distinction which would distinguish active entrainment (participant entraining with dancer through synchronising to a common beat), from passive entrainment (participant watching dancer synchronising to external beat). Although this experiment did find a preference for watching the synchronous dancer, which could indicate an entrainment to the music, the pro-social effects of entrainment were not found. However, it has been proposed that passive entrainment is a 'weaker' form of entrainment, showing the same effects as active but to a lesser extent. If passive entrainment has a weaker effect on pro-social behaviour than active, the way in which this experiment examined memory may not have been sufficiently fine-grained to demonstrate the effect. This experiment, then, adds to the minimal passive entrainment literature and has implications for pro-social theories of dance (and the passive observer).

To further this research, the experiment could be re-run with several adjustments. Different dancers could be used for each condition (each being filmed dancing both in and out of synchrony with the music to account for the effect of individual differences) and facial information could be provided on answer forms, as in Woolhouse and Tidhar (2010). Memory of sashes and prints could be ascertained as opposed to 'hair piece colour', 'belt colour' etc. Perhaps most interesting, would be a comparison of the current study with a replication in which participants were required to simultaneously entrain to the music whilst watching the dance videos, for example by finger or foot tapping.

These modifications may lead to the enhanced social-memory effects of Dance I, whilst providing more detailed information regarding gaze times. However, it could be found that even these alterations move too far from the original paradigm to show enhanced social-memory, and that more detailed data can only be collected from a naturalistic dance situation. Alternatively, this experiment could be furthered by directly examining the differences between active and passive entrainment, for example through running one of the suggested experiments in both an active and a passive paradigm.

ACKNOWLEDGMENT

I would like to thank all of the members of the Centre of Music and Science, University of Cambridge that helped in the development of this project, and that gave up their time for discussion of the findings.

REFERENCES

Clayton, M., Sager, R., & Will, U. (2005). In time with the music: The concept of entrainment and its significance for ethnomusicology. *European Meetings in Ethnomusicology, 11,* 3-142.

Cross, E., Hamilton, A., Kraemer, D., Kelley, W., & Grafton, S. (2009). Dissociable substrates for body motion and physical experience in the human action observation network. *European Journal of Neuroscience*, 30(7), 1383-1392.

Cross, I., & Woodruff, G. (2008). Music as a communicative medium. In K. Knight K & C. Henshilwood (Eds.) *The prehistory of language (Vol. 1).* Oxford, Oxford University Press.

Kirschner, S., & Tomasello, M. (2010). Joint music making promotes prosocial behaviour in 4-year-old children. *Evolution and Human Behavior*, *31*(5), 354-364.

Louw, D., & Ventner, A. (2004). The relationship between memory and the recall of specific details. *Medicine and Law*, *23*, 625-655.

Macrae, N., Duffy, O., Miles, L., & Lawrence, J. (2008). A case of hand waving. *Cognition*, *109*(1), 152-156.

Mast, M., & Hall, J. (2006). Women's advantage at remembering others' appearance: A systematic look at the why and when of a gender difference. *Personality and Social Psychology Bulletin*, *32*(3), 353-364.

Mehta, R., & Zhou, R. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science Magazine*, *323*(5918), 1226-1229.

Mitchell, R., & Gallacher, M. (2001). Embodying music: Matching music and dance in memory. *Music Perception*, *19*(1), 65-85.

Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: Bodies and minds moving together. *Trends in Cognitive Sciences, 10*(2), 70-76.

Stevens, C., Winskel, H., Howell, C., Vidal, L., Laimer, C., & Milne-Home, J. (2010). Perceiving dance: Schematic expectations guide experts' scanning of a contemporary dance film. *Journal of Dance Medicine and Science*, *14*(1), 19-25.

Vatakis, A., & Spence, C. (2006). Audiovisual synchrony perception for speech and music assessed using a temporal order judgement task. *Neuroscience Letters*, *393*(1), 40-44.

Vatakis, A., & Spence, C. (2010). Audiovisual temporal integration for complex speech, object-action, animal call, and musical stimuli. In M. J. Naumer & J. Kaiser (Eds.), *Multisensory Object Perception in the Primate Brain*. New York, Springer.

Woolhouse, M., & Tidhar, D. (2010). Group dancing leads to increased person-perception. *Proceedings of the 11th ICMPC*, Seattle, USA, 605-608.